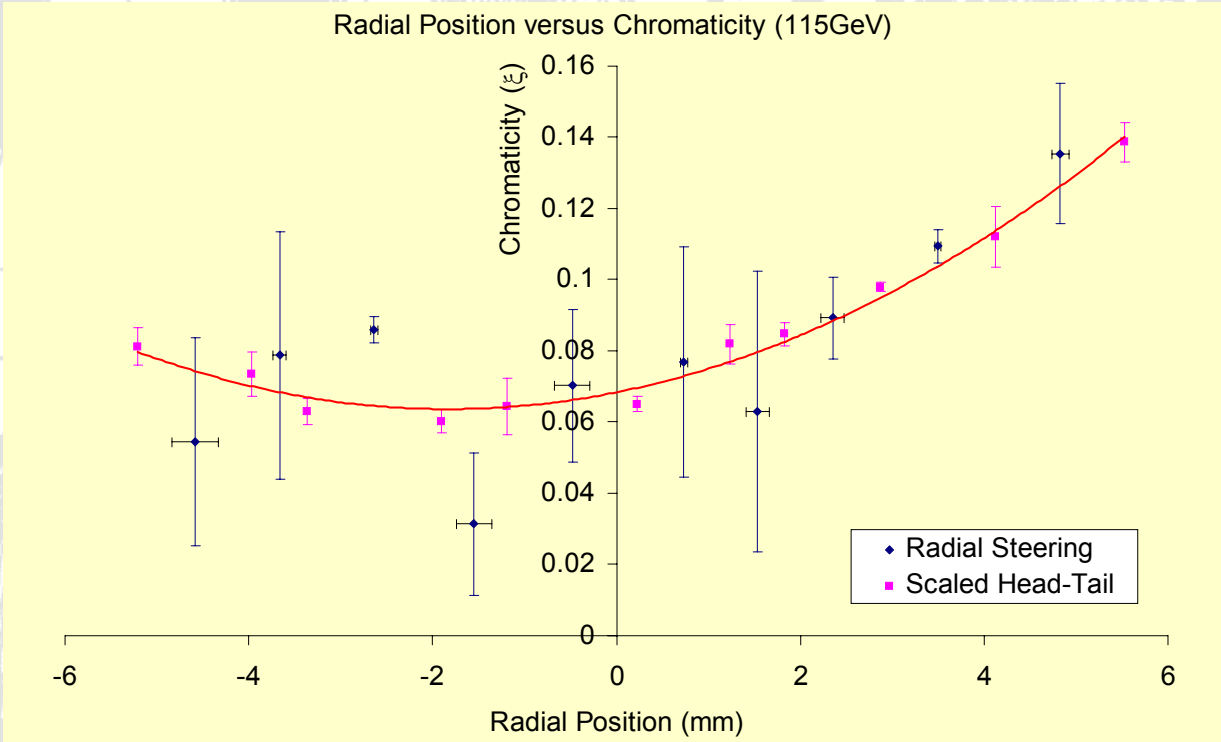
Work at CERN towards LHC q- and q ’- control



RHIC-retreat, March 2002

H.Schmickler, CERN SL-BI

Outline

This is the focus of the talk

- Q, Q'-Control =
  1) q,q' time resolved measurements (tracking), which are absolutely reliable as input to an automated feedback algorithm;
  NO fancy Diagnostic tool
  2) + some "slow control", correction elements…
- PLL techniques are commonly believed to be the best choice for q-tracking
  --> limitations, proposed R&D
- The search for direct Q' observables
- Summary
- Recommendations for RHIC

Principle of PLL tune measurements

This PLL system looks to the 90 deg. point of the BTF; cos (90)=0, no change of VCO

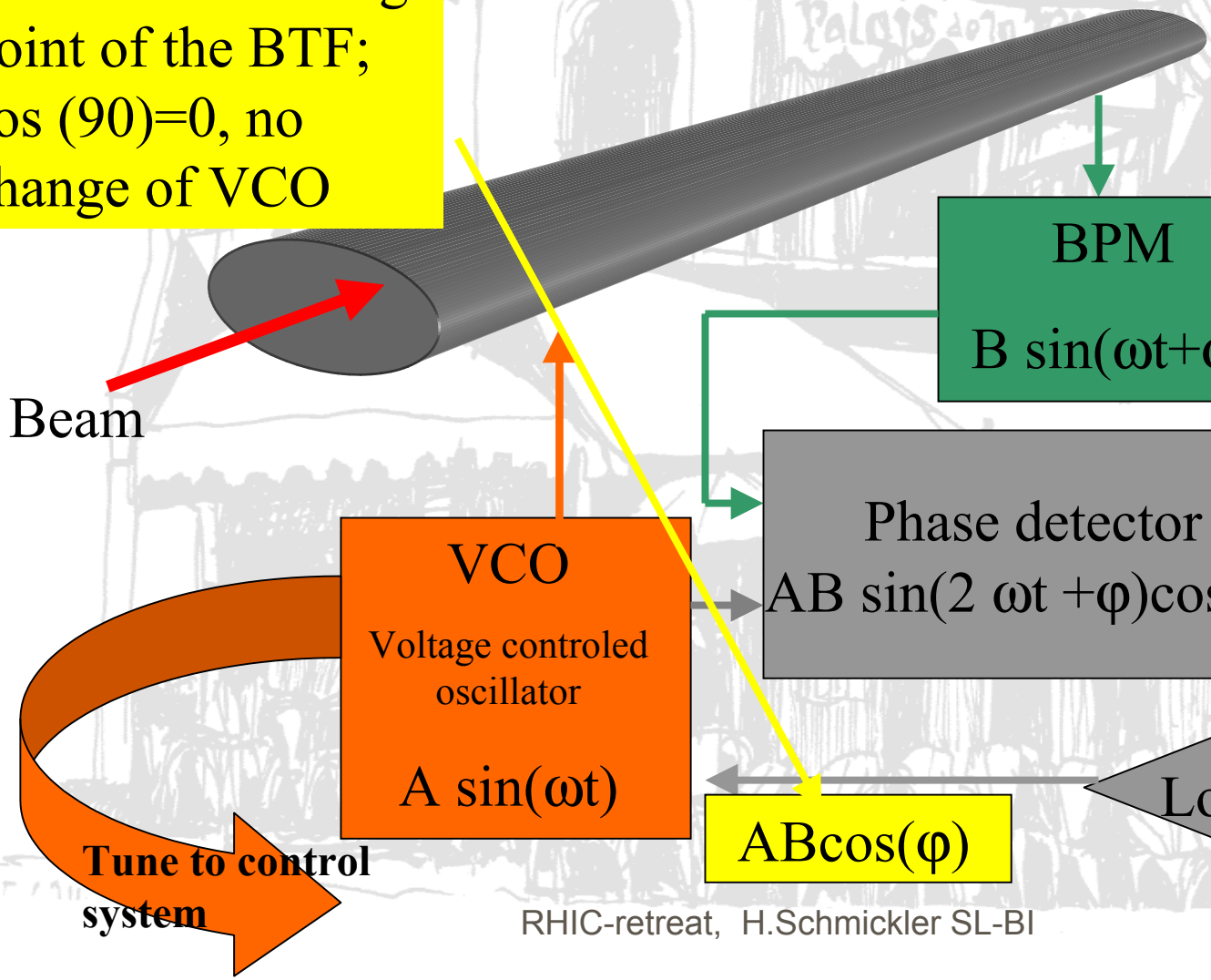
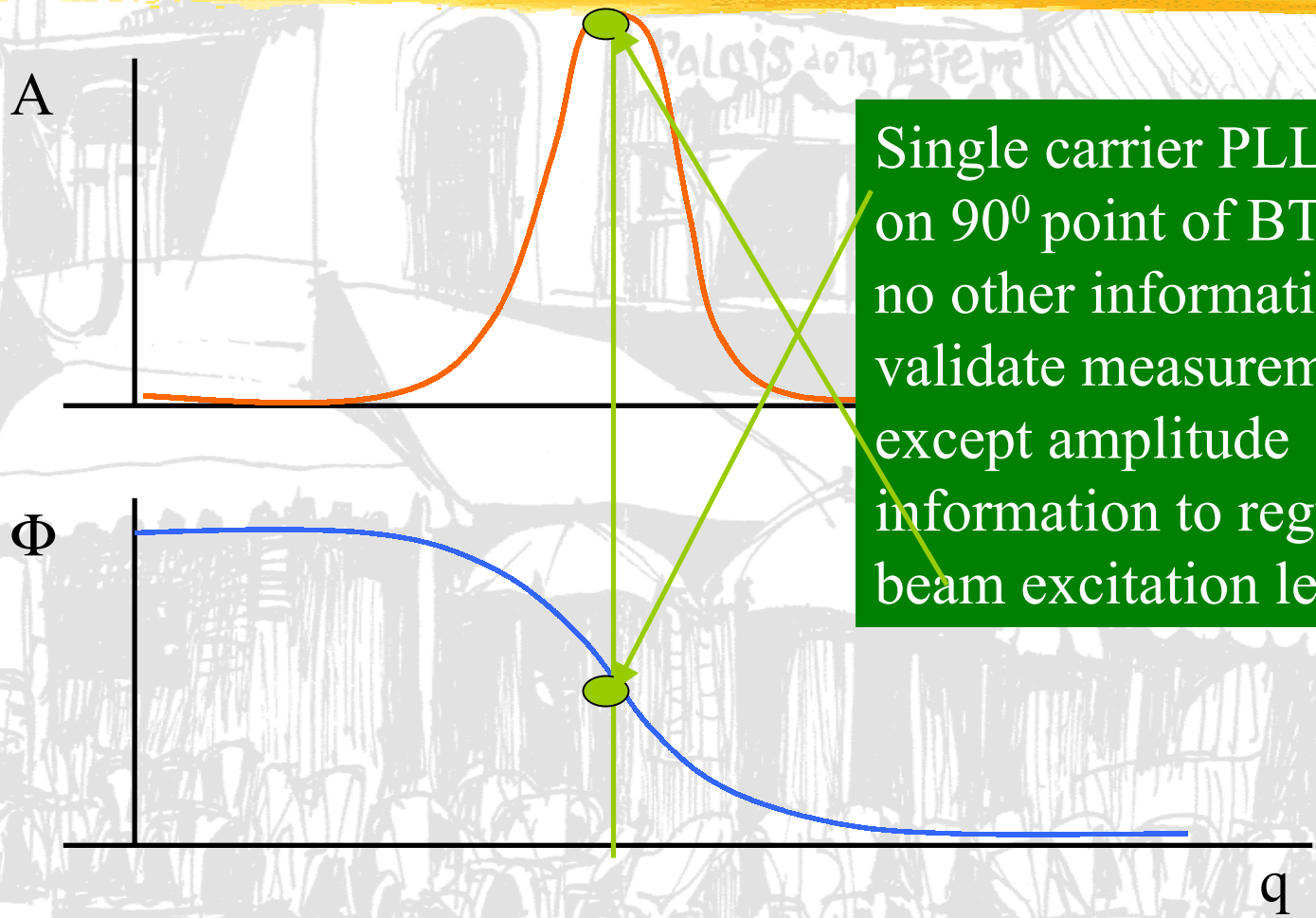
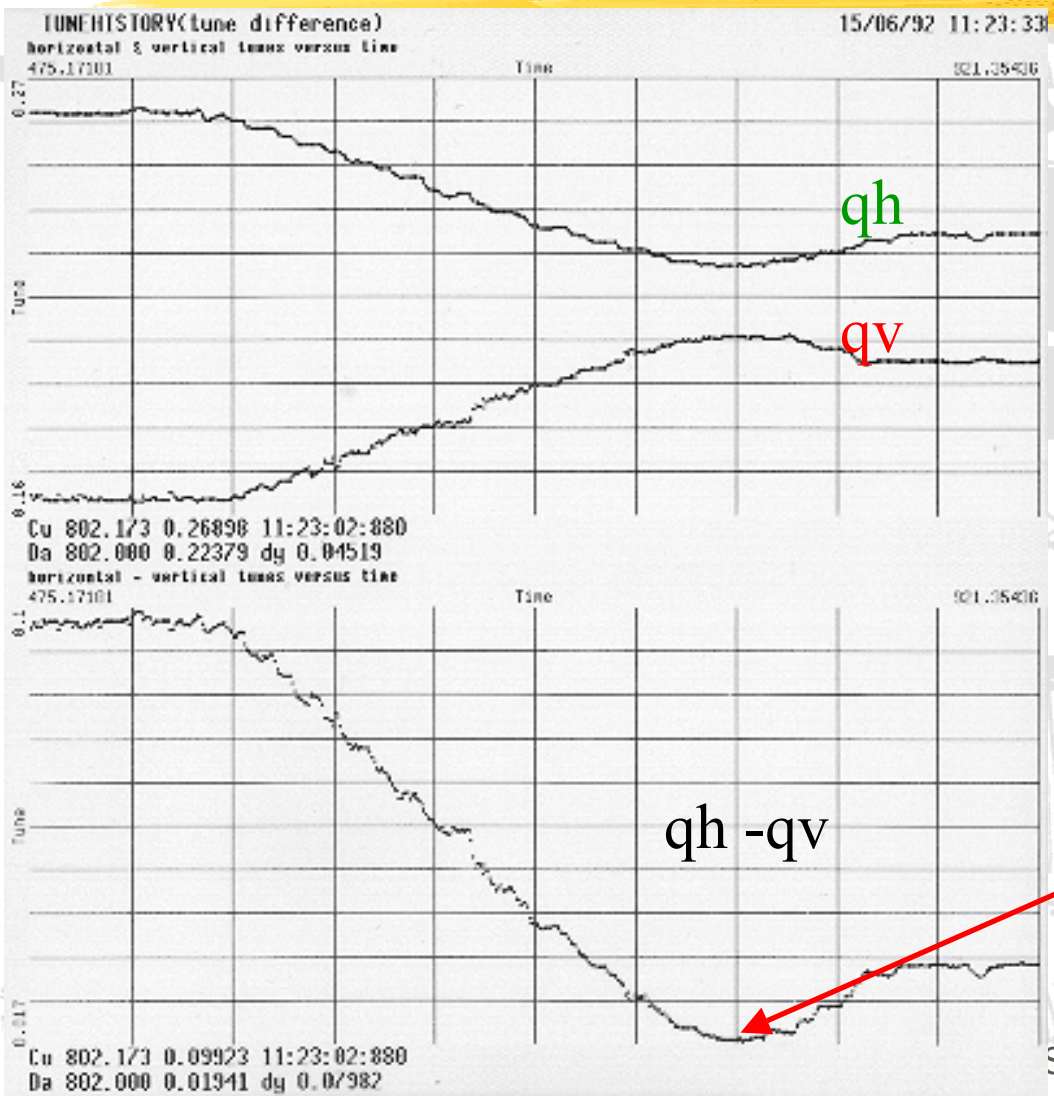


Illustration of single Carrier PLL



Single carrier PLL locks on 90^0 point of BTF; no other information to validate measurement; except amplitude information to regulate beam excitation level

Example of PLL tune measurement



In this case the continuous tune tracking was used whilst crossing the horizontal and vertical tunes with a power converter ramp.

The closest tune approach is a measure for coupling

Limitations of PLL tune tracking

- constant (CW) beam excitation --> emittance growth
(can be minimized to tolerable levels with high sensitivity BPMs -
- sensitivity to other signals in BTF:
1)other plane via coupling (results in wrong measurement)
2)change in slope of BTF due to chromaticity
results in wrong loop gain and hence more noise, or
loss of lock due to too low excitation, or beam blow-up…
3)sensitivity to synchrotron side-bands (impressive "bad" examples from RHI
- single observable = frequency of VCO;
no control of quality of measurement

Proposed solution (R&D):
multiple carrier excitation, fully digital implementation,
fuzzy logic for extraction of observables

BTF measurements at RHIC (P.Cameron)

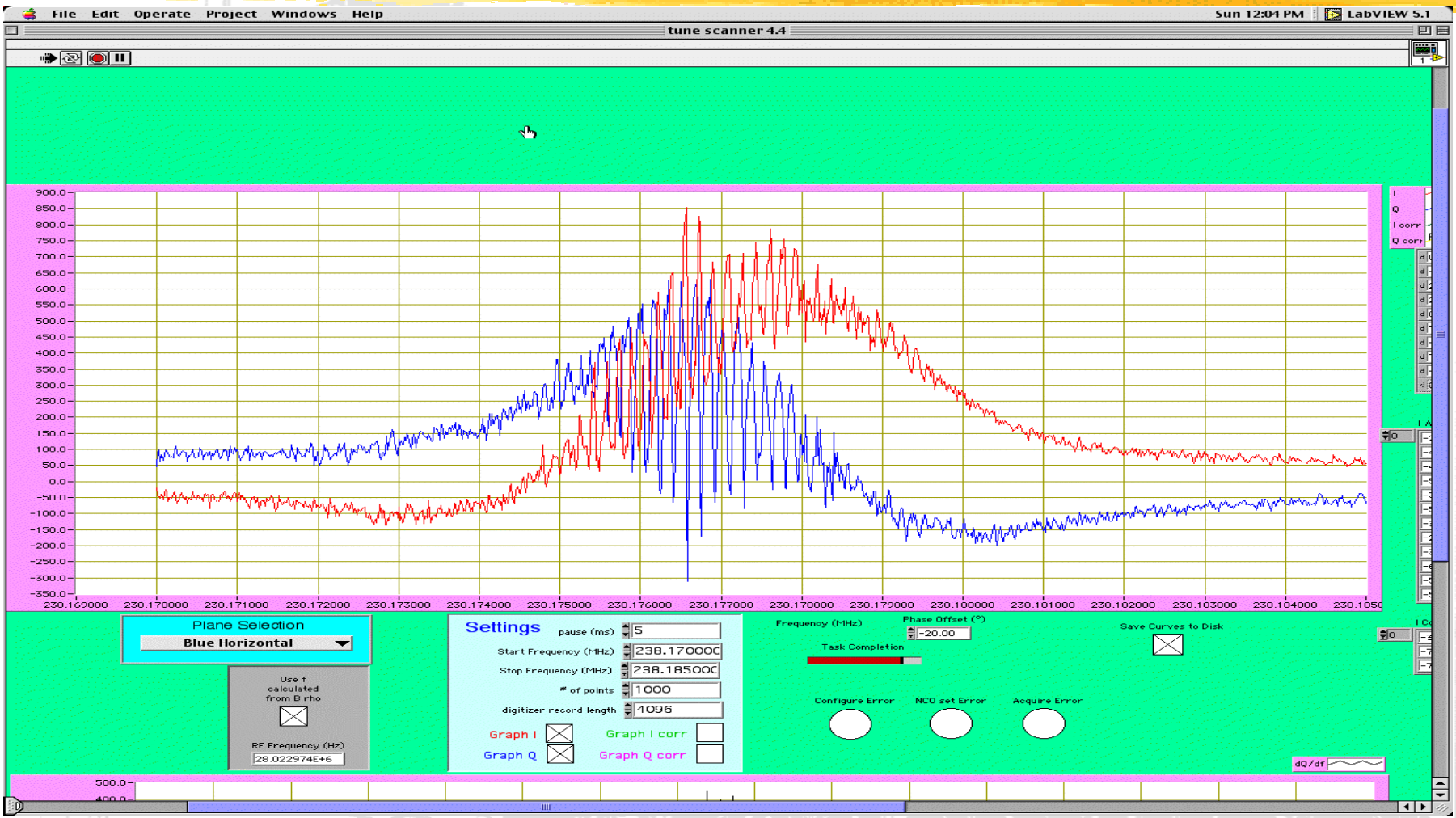
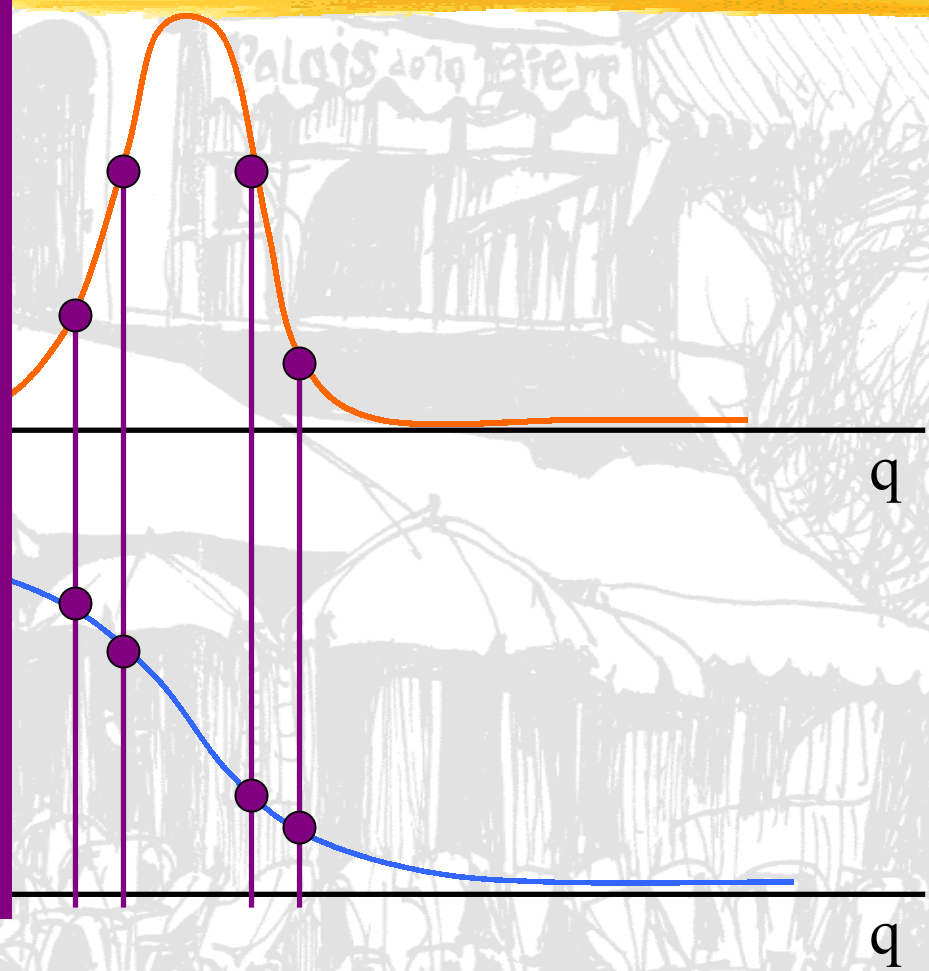


Illustration of multi-Carrier PLL

Multi Carrier PLL (n=4 carrier lines shown here) locks on combination on several phasepoints of BTF; additional information (symmetry, width…) is available to validate measurements;
in case of n>>10 one could speak of an online measurement of the BTF



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What observable to choose for Chromaticity (Q')?

$$\Delta Q = Q' \frac{\Delta p}{p} = \left(\frac{1}{\gamma^2} - \alpha \right) Q' \frac{\Delta f}{f}$$

1) Tu[illegible]nce for different [illegible] ↔ used at HERA, LEP, RHIC in combination with PLL tune tracking

[illegible]idth of tune peak or damping time ↔ model dependent, non-linear effects, Used extensively at DESY

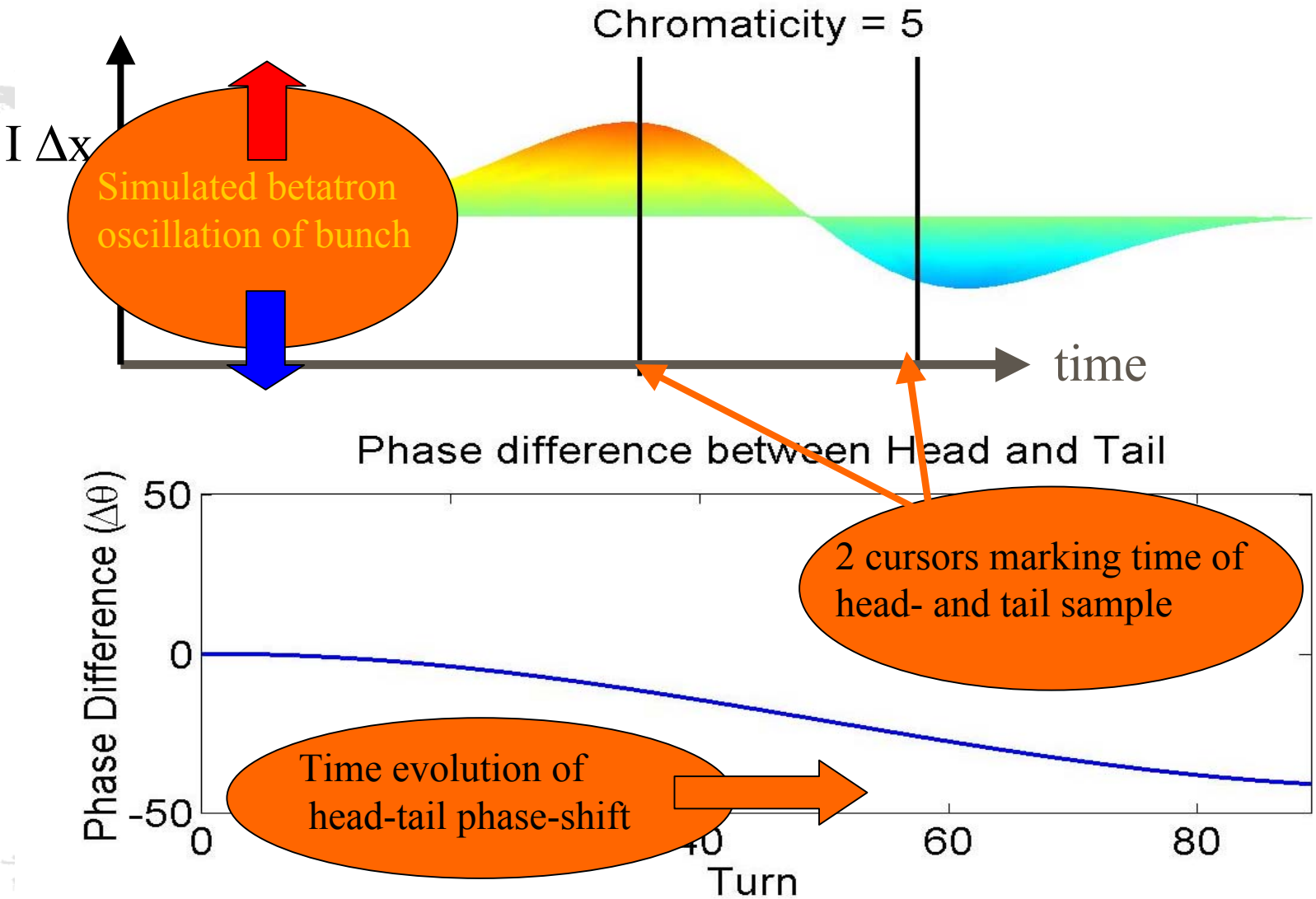
3) amplitude ratio of synchrotron sidebands ↔ Difficult of exploit in hadron machines with low synchrotron tune, influence of lattice resonances?

[illegible]f energy oscillations and [illegible]racking ↔ First promising steps at SPS

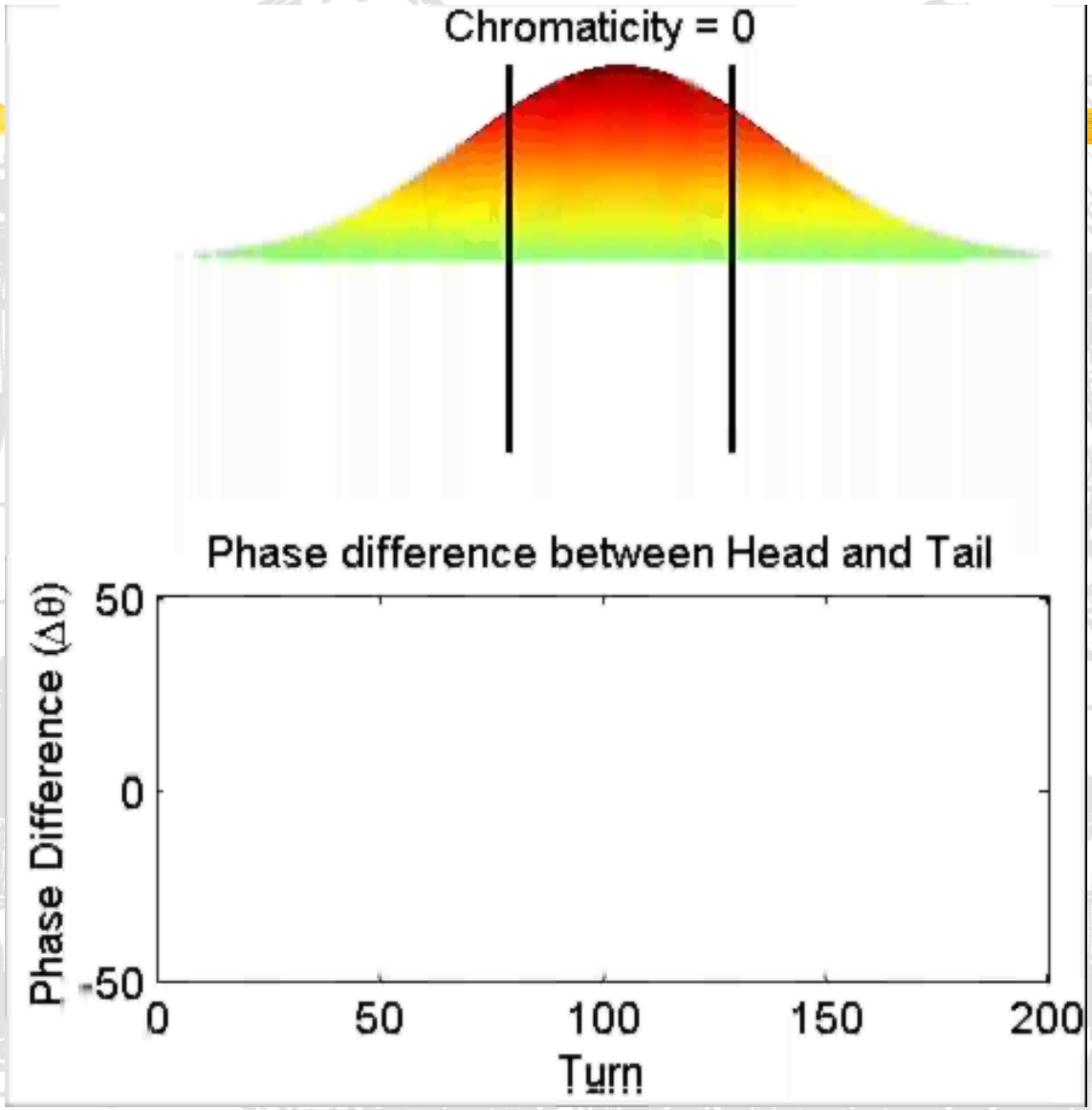
5) bunch spectrum variations during betatron oscillations ↔ difficult to measure

6) Head-tail phase advance (same as 5, but in time domain) ↔ very good results, requires kick stimulus, emittance growth!

...snapshot of movies to follow...



The Head-Tail Principle



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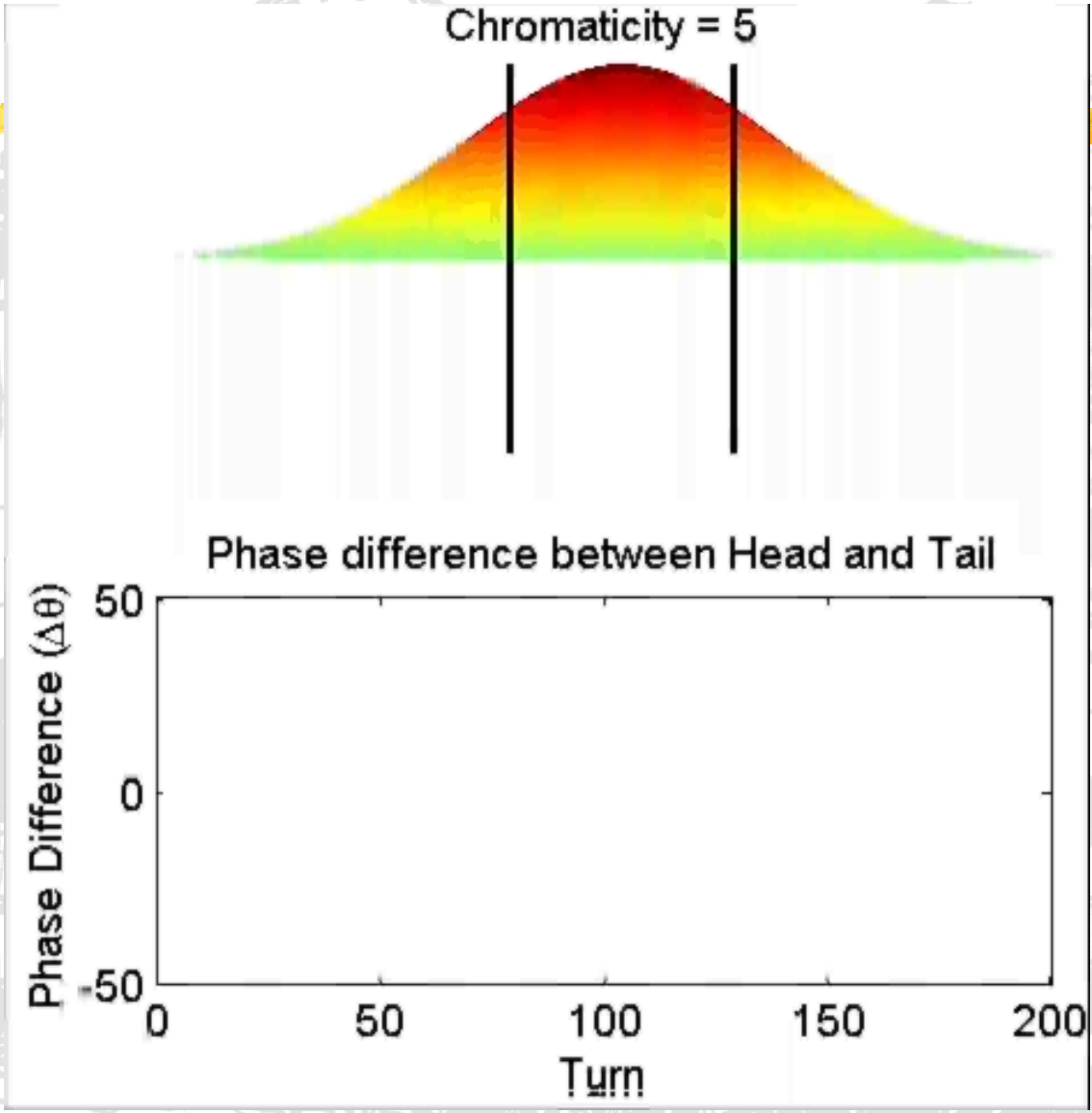
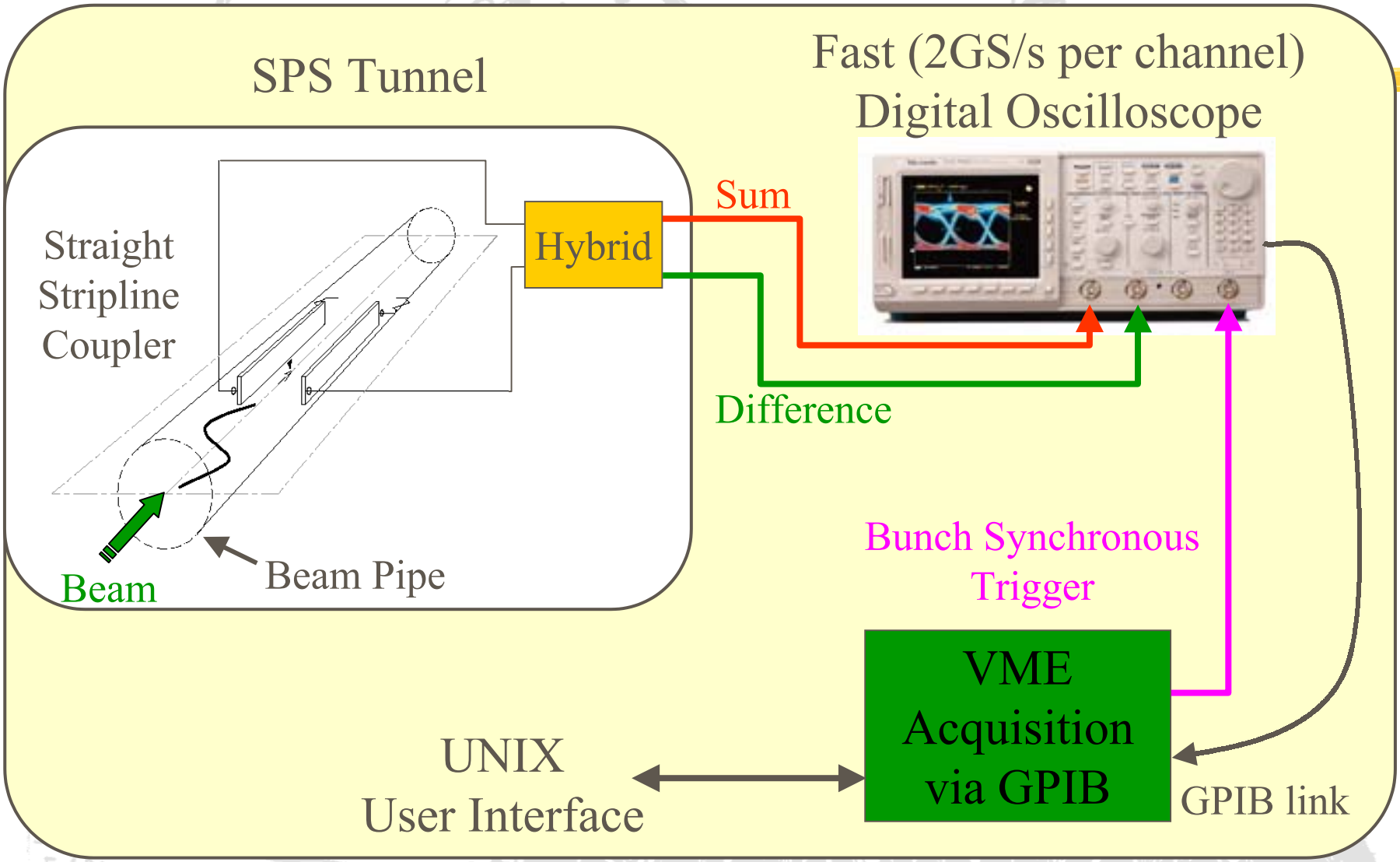
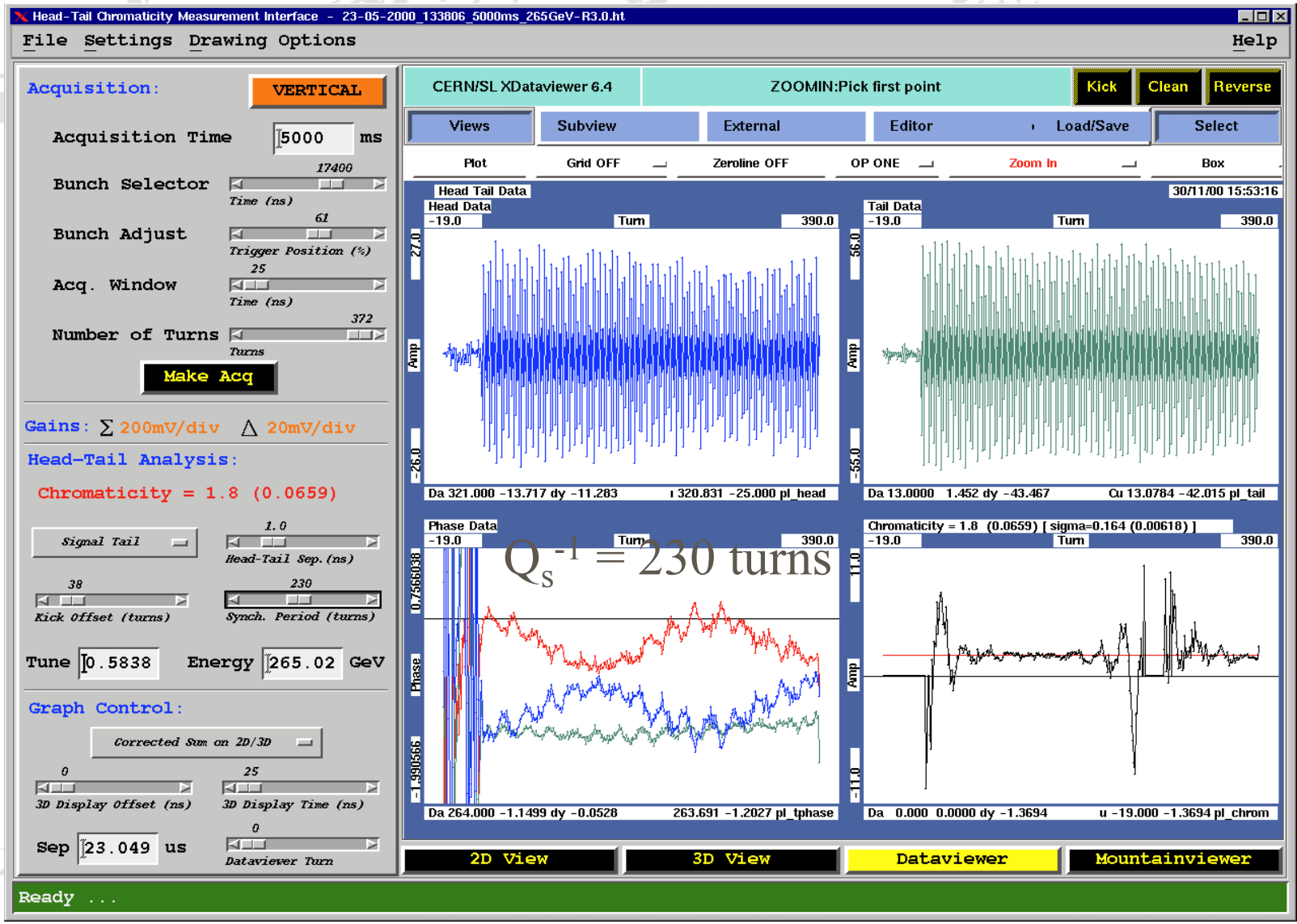


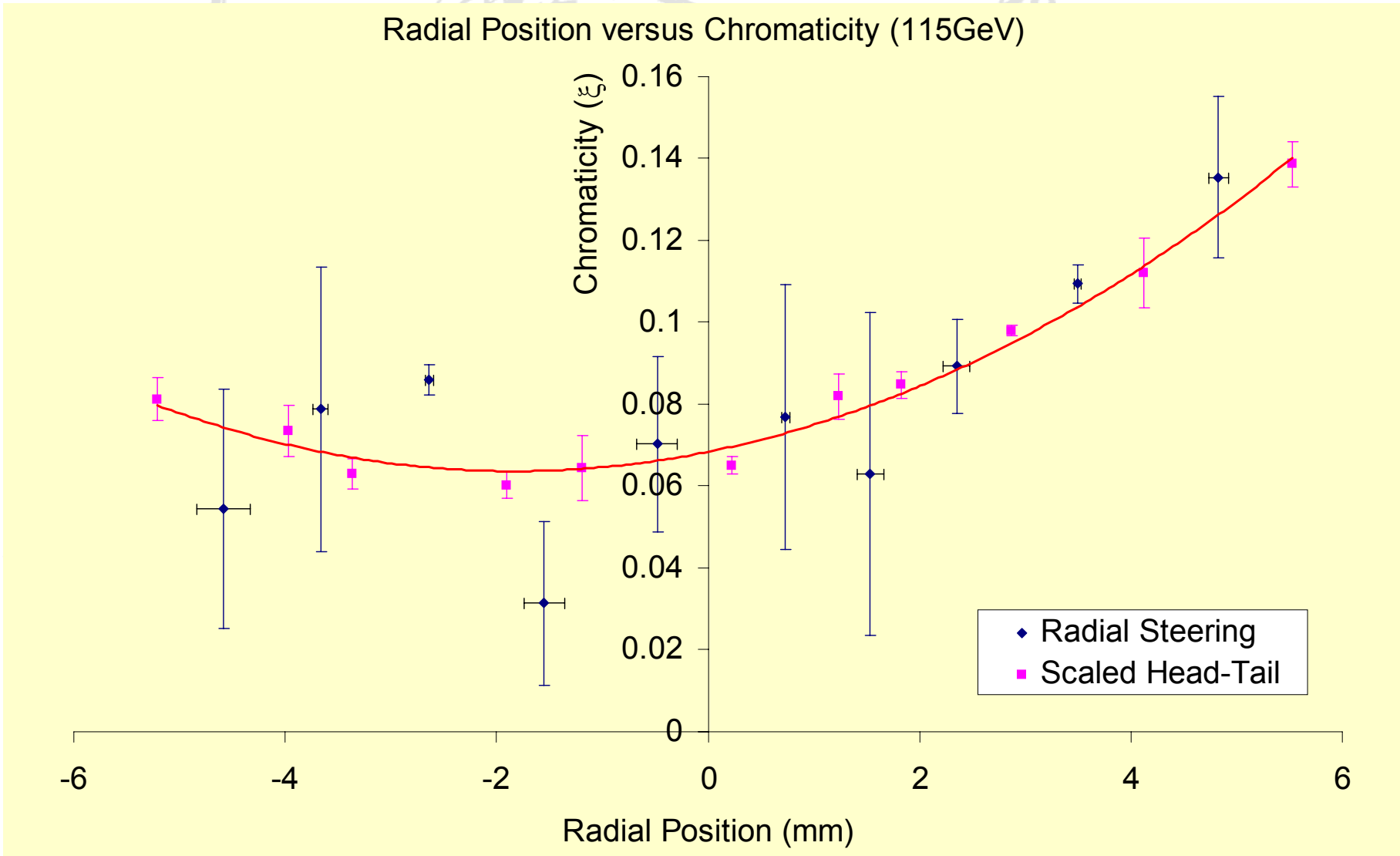
Head-Tail System Set-up (SPS)



Measuring Q' (Ex 1: low Qs)



Measuring Q”


Radial Position versus Chromaticity (115GeV)
Chromaticity (ξ)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-6
-4
-2
0
2
4
6
Radial Position (mm)
Radial Steering
Scaled Head-Tail

Summary

- PLL q-tracking best option for q-control (combined with high sensitivity pickup; oscillation amplitudes in the um range)
- Still needed:
  - R&D on multiple Carrier excitation, fuzzy logic for online interpretation of results, demands fully digital realization
  - measurement campaign at SPS, HERA-P and RHIC of BTFs at various beam conditions. Make modell PLL lock on right tune under those conditions (tbd 2002)
  - full simulation tool for prediction of observables (work started in 1998 in collaboration with TRIUMF, needs much bigger effort)
  - Test realizations of PLL at SPS and/or RHIC and/or HERA
- Head-Tail Chromaticity Diagnostics is a very powerful diagnostics tool, but it is probably not adequate for q'-control
- Continuous excitation of energy oscillations and (high bandwidth) PLL tune tracking combines q and q'-tracking into the same instrument.

Recommendations for RHIC for 2002

- Major step in getting an "operational" q-tracking system
  Full integration of PLL settings into control system: Different settings for production runs or diagnostics runs
- Further regulation loop for beam excitation; will help solving the dependence on chromaticity (and beam energy)
- Measure QH and QV on different bunches; this will gain some margin for coupling sensitivity
- Clean up BTF, which is "visible" for PLL:
  - suggestion:
  install one additional BPM/plane/ring at 180 degrees in betatron phase to existing BPMs.
  Make PLL work on difference of both signals.